Why hasn't high-frequency trading swept the board? Shares, sovereign bonds and the politics of market structure

Why Hasn't High-Frequency Trading Swept the Board?

Shares, Sovereign Bonds and the Politics of Market Structure

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Abstract

In today's trading of liquid financial instruments, there are two main contending *agencements* (in Callon's 'actor-network' sense of combinations of humans and nonhuman elements that manifest distributed agency): one *agencement* yokes together automated high-frequency trading (HFT) and open, anonymous electronic order books; the other is organized above all around the distinction between 'dealers' and 'clients'. Drawing upon interviews with 321 market participants, we examine differences in the relative presence of the two *agencements*. We focus in this article on the processes that have given rise to especially sharp differences between the trading of shares and of sovereign bonds, and between the trading of the latter in the US and Europe. The article contributes to two literatures: the sociological literature on trading (especially on HFT), which we argue needs expanded to encompass what can be

called ‘the politics of market structure’; and the nascent political-economy literature on the processes shaping how sovereign bonds are traded. In terms of underlying theory, we advocate far greater attention in actor-network economic sociology to the state and its agencies and a stronger focus in political economy on materiality.

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Introduction

A fundamental divide runs through today's financial trading. Some trading involves advanced technology, rapid data dissemination and order placement, automation and anonymity: the world of high-frequency trading. Other trading is more human-centred, human-paced and often opaque. Data dissemination is at times deliberately slow and personal relationships and trust continue to play central roles. This article investigates stark differences in the prevalence of these two forms, focusing on the trading in shares and in sovereign bonds in the US and Europe. We conceptualize both forms as *agencements*. Although the academic concept has its roots in the work of Deleuze and Guattari (1975; see also 2004), the way in which we use it follows Callon (2005 and 2007). As in everyday French, an *agencement* is an arrangement: in Callon's words 'a combination of heterogeneous elements', both human beings and 'non-humans' such as technical artefacts, objects, etc., or in our case algorithms and order books (Callon 2007, p. 320). The 'actor-network theory' to which Callon's work belongs (along with that of Latour, Mol, Law and many others) emphatically rejects, however, the everyday assumption of passive things configured by an active human 'arranger'. The term *agencement* contains a deliberate pun (missing in its standard English translation as 'assemblage') with *agence*, agency. Callon's – indeed, actor-network theory's – core argument is that agency is distributed. The capacity to act belongs with the entire arrangement, not with its human components alone: '*agencements* are arrangements endowed with a capacity of acting in different ways depending on their configuration' (Callon 2007, p. 320).[1]

Consider what we conceptualize as the high-frequency trading/anonymous order-book *agencement*. First, HFT cannot be reduced to the goals, actions or beliefs of the human beings

[1] In contrast to the more widely used notion of 'assemblage', the term *agencement* thus more explicitly follows the prescription – at the core of actor-network theory – to avoid making *a priori* distinctions between human agents and the things they 'assemble' or 'arrange' (Callon 2007, p. 320; see also Braun 2016; for an analysis with the similar concept of 'distributed agency' see Langley and Leaver 2012).

involved: it is intrinsically sociomaterial, and the human beings involved do not control the actions of HFT algorithms in any detail, and quite often do not fully understand those actions.[2] Second, more is involved in HFT's materiality than simply HFT firms' algorithms and technical systems. The *agencement* also includes the exchanges or other trading venues on which this form of trading takes place, where an 'exchange' is not simply an organization but also a material system. HFT has historically been linked tightly to markets structured around anonymous, open, electronic order books (see Figure 1). Any market participant can directly enter into such an order book anonymous bids to buy and offers to sell the financial instrument being traded, and can 'see' (in an electronically mediated fashion) others' anonymous bids and offers. Third, high-frequency trading and exchanges shape each other sociomaterially: not only must HFT adapt to the characteristics of exchanges' technical systems, but competition among exchanges for market share means their systems also have to adapt to HFT. Fourth, in the full-blown form of the *agencement* found in share trading in the US and Europe (and, increasingly, in much of the rest of the world too), the term 'have to' in the previous sentence is correct. Exchanges have choices, but even exchanges such as IEX that are – simplistically – thought of as anti-HFT (Lewis, 2014) are shaped by it. The HFT/anonymous order-book *agencement* is demiurgic: it changes things, in a way that – once again – is not reducible to human intentionality. It is an 'acentred system … without a central agency' (Deleuze and Guattari, 2004, p. 17), but it *does* things and changes things.

[2] The materiality on which this article (and indeed most actor-network studies) focuses is sociomateriality, namely the concrete practices and processes that involve both human and non-human beings as actors or, more precisely, 'actants'. For an analysis of HFT's (socio)materiality see author (2018). How 'materality matters' and the role of devices in shaping or constituting financial market practice has been an important focal point of the social studies of finance, which have scrutinised the sociomateriality of, *inter alia,* calculators (Beunza and Muniesa, 2005), financial models (Svetlova 2018), trading rooms (Beunza and Stark, 2004), screens (Knorr Cetina, 2005) and investor portals (Roscoe 2013).

What HFT confronts is a second, older *agencement* that is also sociomaterial, but in which what one might call the 'relative weight' of human beings and interpersonal relationships is greater. We call this *agencement* the 'dealer-client *agencement*', because that distinction between roles is what structures it (see Figure 2). In a dealer-client market, those organizations that are classed as 'clients' (which can include even the biggest hedge funds, investment-management firms or non-financial corporations, along with, e.g., smaller banks) do not trade directly among themselves, but only via dealers. In contrast, dealers trade both with clients and with each other, in the latter case often via interdealer brokers. In a dealer-client *agencement*, in other words, dealers are 'price-makers' (disseminating, either continuously or on request, the prices at which they will trade), while clients are essentially 'price-takers'. The dealer-client distinction is not utterly rigid, but nevertheless structures how trading takes place (see Table 1 for a summary of the main differences between the two *agencements)*.

Dealer-client financial markets took their modern form in the middle decades of the twentieth century, replacing face-to-face interaction on exchanges (the New York Stock Exchange or NYSE, London Stock Exchange, Paris *Bourse*, etc.) that historically had traded not just shares but also sovereign bonds. Although visual display screens came into use in dealer-client markets in the 1960s as a way of disseminating indicative prices, the technology that had initially allowed face-to-face trading to be bypassed was the telephone (Meeker, 1930, p. 260). Clients wanting to buy or sell telephoned (and often still telephone) dealers, while interdealer brokers installed dedicated, permanently open telephone lines over which they talked (and still talk) throughout the trading day to dealers. Over the last twenty years, this use of the human voice and the telephone in the dealer-client *agencement* has been complemented and to a degree supplanted by electronic trading. Crucially, though, that

electronic trading remains largely bifurcated, with anonymous interdealer markets (such as BrokerTec) and separate non-anonymous dealer-client markets (such as Bloomberg FIT).

The HFT/anonymous order book *agencement* has taken firm hold in some markets, for example in the trading of shares in the US, Europe, and much of the rest of the world. However, the dealer-client structure of other markets remains little altered: see Table 2, and also the quantitative data in Table 3. Notably, there is almost no high-frequency trading of Eurozone sovereign bonds, UK gilts, or other European sovereign debt. We have found other cases to be mixed. In US Treasurys, for instance, the HFT/order book *agencement* has colonized and thoroughly transformed the interdealer market, but has made only very limited inroads into the dealer-client market. Why these very different outcomes? What explains the capacity of some 'market structures' (market participants' typical term for how trading is organized) to persist, while other market structures crumble?[3]

These are, we would suggest, quintessentially political questions[4], yet the literature of international political economy (IPE) has addressed them only obliquely, while the literature in sociology on trading (including the emergent sociological literature on HFT) has so far scarcely asked them.[5] Investigating, as we therefore do, the politics of market structure does

[3] For a demonstration of the importance of sovereign-bond market structure to the capacity of emerging-market governments to borrow, see author (2011, 2012 and 2019). What participants mean by 'market structure' is similar to what financial economists (following Garman, 1976) call 'market microstructure': 'the process by which investors' latent demands are ultimately translated into prices and volumes' (Madhavan, 2000, p. 205). The literature in economics on market microstructure is valuable, but is largely 'depoliticized'. Although contributors to it are certainly aware that market structure is often the focus of intense conflict, that conflict is seldom if ever the focus of their analytical attention.

[4] This article does not take a normative position regarding the merits of HFT, the primary dealer system or any underlying disputes.

[5] The closest the literature on HFT has come to addressing the politics of market structure is perhaps Castelle et al. (2016) and Coombs (2016). Important contributions that do not deal with that issue include Lange (2016) and Borch et al. (2015).

not, though, involve abandoning the actor-network (ANT) emphasis on *agencements* and materiality. Our argument, rather, is that actor-network analyses of trading need a stronger focus on issues of the state and politics, while work on finance in the political-economy tradition should be more attentive to trading's materiality. It is, for example, quite impossible to understand today's politics of market structure without grasping a central material consideration on which our interviewees were agreed: that HFT firms' technical systems are nearly always faster than those of even the largest and most sophisticated banks. While the performativity thesis (one of ANT's offshoots) has been embraced by IPE scholarship (e.g. Braun, 2016; Heimberger and Kapeller, 2017; Lockwood, 2015), barring a few exceptions (notably Campbell-Verduyn et al., 2019) ANT more broadly has thus far eluded sustained engagement. Complementing this article's empirical contribution, we wish to take up recent calls for productive engagement between IPE and ANT (Best and Walters, 2013; Campbell-Verduyn et al., 2019).

In so doing, we seek to advance this nascent dialogue by focusing on very different outcomes in the financial markets we consider and the politics leading to those outcomes. The materiality ANT encourages us to analyse, in other words, cannot explain outcomes on its own: the fastest trading systems do not inevitably determine market structure. Governments and their agencies, we suggest below, have had an important influence on the evolution of market structures in the trading of both shares and sovereign bonds, albeit in entirely different ways. Viewing the role of the state actors in field-theoretical terms focuses on the interdependent relation between state actors and market participants.[6] In all four of our cases (shares and sovereign bonds in the US and Europe), the struggle between what field theorists label as 'incumbent' market actors, whose relative dominance is reflected in market

[6] In viewing politics in field-theoretical terms, we adopt a narrow understanding of the political that focuses on the role of the state and direct state regulation. As indicated, for instance, by literature which conceptualizes politics in terms of 'governmentality', it is also possible to conceive of politics as governance beyond the state.

practices, and the 'challengers', or those actors that strategically seek to upend the normal state of affairs, has been a key factor in the evolutionary processes of market structures too (Bourdieu, 1997; Fligstein 2001; Fligstein & McAdam 2012). Field theory – at least in its institutional rendition by Neil Fligstein and others – posits the idea 'that incumbents and challengers are engaged in an iterative strategic dance, continuously modifying their strategies and tactics in response to the earlier moves of other actors in the field' (Fligstein and McAdam, 2012, 84). Crucially, Fligstein and McAdam (2012) see state actors as key actors not only in the emergence of new market fields but also as an external resource on which incumbents may come to rely for the reproduction of their dominant position within a given market.

The addition of a field-theoretic perspective to ANT's potential contribution to IPE therefore highlights the ways in which technological developments and the conflicts they can cause result in change, and speaks loudly to some of IPE's key research themes, namely the structure of international finance, public/private power, and the role of agency, in addition to specific research strands within the discipline, notably HFT (e.g. Campbell-Verduyn et al., 2017), central clearing (e.g. Lockwood, 2018; Gabor and Ban, 2015), and debt management (e.g. Fastenrath et al., 2017).

The remainder of this article is divided into four parts. We first discuss our approach. In part II, we analyse the *agencement* of HFT in the trading of shares, noting striking similarities in Europe and US. In part III, we turn our attention to the market for sovereign bonds and find not only that this *agencement* differs markedly from the one described for shares, but also that there are important differences between the European and the US sovereign bond markets. Part IV concludes.

Cases and Data Sources

The research underpinning this article encompasses all the classes of financial instruments that are *sufficiently liquid* that high-frequency trading of them seems, in principle, possible: shares, sovereign bonds, futures, foreign exchange, listed options and interest-rate swaps. Examining all of these in a single article is impossible, so our approach is to focus here on shares and sovereign bonds (traders in both markets will commonly also trade futures). This selection is motivated by two key factors. First, both are simple, standard, liquid securities, which, as already noted, used to be traded in the same way in the same trading venues. Secondly, as is shown by the data in Table 3, they are now traded in quite different ways – including, in the case of sovereign bonds, differently between the US and Europe. Our goal in this article is to highlight important processes that have led to these different outcomes, with the aim of contributing to the development of hypotheses regarding those outcomes.

Our focus on the trading of Treasurys and other sovereign bonds has a virtue quite separate from the sharp contrast with the trading of shares. US Treasurys are, arguably, the world's most important securities: they are not simply how the Federal government funds its deficit, but also the quintessential 'safe haven' or 'shock absorber' of the financial system, high-quality collateral that oils the wheels of finance (Gabor, 2016), and the most salient single form in which overseas central banks hold their foreign-exchange reserves. It is, therefore, striking that we can find no sociological or IPE work on the mechanisms of Treasurys trading since the pioneering ethnography of the late-1980s' Treasurys market by Abolafia (1996, chapter 1). It is as if scholars have implicitly shared the viewpoint on trading that seems to have been held by US officials (at least until violent, and still not fully explained, price gyrations in Treasurys in a 12-minute period in the morning of 15 October 2014: see below): that the Treasurys market 'works' – enables the US to borrow on a large scale and cheaply – and detailed attention to its structure is therefore not needed.

In contrast, most European governments have not been able to be complacent about borrowing, and the project of European Economic and Monetary Union fundamentally altered the situation of the governments of what became the Eurozone. IPE scholars (Dutta, 2018; Fastenrath et al., 2017; Lagna, 2016; Preunkert, 2017; Trampusch, 2015) have identified active efforts by European governments from the 1980s onwards to shape the markets for their sovereign bonds, and thus implicitly have begun to trace the origins – much more recent in Europe than in the US – of the dealer-client *agencement*. European 'states mobilize[d] markets for particular policy aims' (Dutta, 2018, p. 7), especially to enhance their capacity to borrow. They imported American practices such as bond auctions and the designation of primary dealers with obligations to bid in those auctions and to facilitate subsequent 'secondary' trading of sovereign bonds.

In the different outcomes between share and bond trading, we see the dynamic interactions between state and market actors as a key driver in the advancement (or impediment) of the HFT/anonymous order-book *agencement*. In the case of share trading, state actors in both the US and Europe perceived the changes, which inadvertently facilitated the rise of 'challenger' HFT firms and alternative trading systems, as an opportunity either to promote competition among traders and exchanges (US) or to pursue the political aim of capital market integration (Europe). In the trading of government bonds, however, our evidence suggests that state actors did not actively facilitate the advancement of the HFT/anonymous order-book *agencement*, ostensibly because of uncertainty about how it would impact the state's ability to finance its debts. This provides one potential hypothesis for the different outcomes between shares and bonds. However, variation also exists between bond markets in the US and Europe. The dealer-client structure of European markets for sovereign debt has remained largely unchanged, while the US market has only seen the partial colonization of trading by the HFT/anonymous order-book *agencement*, which has

made inroads almost exclusively in the interdealer segment of the market. We do not see these differences as driven by the ideological commitments of state actors; our analysis, rather, focuses on possible hypotheses regarding pre-existing market structure and the relation between debt managers and primary dealers.

What we have done in this article, therefore, is to construct primary-source narrative histories of our four cases (US and European share trading; US and European sovereign bond trading), and from those histories – which can be presented here only schematically[7] – sought to explore preliminarily possible causal processes that might help explain the substantial differences among the historical trajectories of the four cases. Since the four cases differ on many dimensions, and idiosyncratic events are sometimes important, we attempt to offer only hypotheses that are subject to revision as further research is done – as we hope it will be – on the four cases. Nevertheless, we are confident that the narratives briefly presented below do capture essential aspects of the trajectories of the four cases.

Our main sources are interviews with 321 market participants, including high-frequency traders, exchange staff, regulators, technology suppliers, traders for institutional-investment firms, and dealers and brokers embedded in the dealer-client *agencement* (see Table 4). The full set of interviews covers not just shares and sovereign bonds, but also futures, foreign exchange, listed options and interest rate swaps. Because of the historically primary role played in changes in market structure by developments in the US, we conducted around two-thirds of the interviews in the main market centers there (117 interviewees are based in New York, and 97 in Chicago), with nearly all the remainder conducted in Europe. Particularly useful was our participation in two meetings attended by staff of government debt management offices of many countries: what they said in informal discussion very

[7] For a fuller account of the evolution of the market structure of US share trading, see (author, 2018).

helpfully complemented sometimes guarded formulations in interviews. We extensively triangulated interview evidence with documentary sources (the trade press, etc.), cross-checked what differently-situated interviewees said about the same events and processes, conducted repeat interviews (sometimes multiple) with particularly well-placed interviewees, and participated in seven industry meetings.

An *Agencement* Triumphant: The Transformation of US and European Share Trading

United States

Crucial components of the HFT/anonymous order book *agencement* first started to come together in the US in the second half of the 1990s in the trading of shares listed on Nasdaq, at that point a conventional dealer-client market in which prices were displayed on-screen but most trading was by telephone. Nasdaq had, though, introduced an electronic Small Order Execution System (SOES), which enabled brokers who serviced retail customers to send the latter's small orders to dealers for automated execution at their on-screen prices. During the October 1987 stockmarket crash, many dealers simply ignored sell orders sent to them via SOES. Among the reforms of share trading imposed by the Securities and Exchange Commission (SEC) after the crash was a rule that dealers *had* to honor their on-screen prices when sent SOES orders (Ingebretsen, 2002). Some traders quickly realized that they could now use SOES profitably to trade against dealers' price quotations that had become 'stale': i.e. out-of-date (interviewee BW). Multiple efforts by Nasdaq dealers to block the activities of these 'SOES bandits' all failed, and a lively culture of semi-professional SOES banditry emerged, especially in lower Manhattan.

In 1995, one of the 'bandit' lower Manhattan brokerages, Datek, set up a new, electronic, anonymous open order-book system, Island, via which bandits could trade with

each other, especially to exit trading positions they had created using SOES. Island (which we discuss in author 2014 and which several of our HFT interviewees had worked for or traded on) was powered by an ultra-fast 'matching engine' (the software that manages an order book), and it offered unprecedently low fees, and also 'rebates': Island made small payments to traders or trading firms when bids or offers they had placed in its order book were executed against, with the goal of encouraging 'market-making' by trading firms (i.e. systematically filling order books with bids and offers). Market-making on Island was further facilitated by having a tick size (a minimum increment of price) of only 1/256th of a dollar, making it straightforward always slightly to improve on the prices being quoted (in the traditional eighths – and, later, sixteenths – of a dollar) by Nasdaq's dealers. Island's success encouraged the establishment in the second half of the 1990s of several other similar trading venues, collectively called Electronic Communications Networks or ECNs, which also competed mainly with Nasdaq's dealers.

The state, however, played a key role through the regulator of share trading, the SEC, whose new rules unconsciously enabled HFT (author, 2018). Setting up new ECNs was made easier by the SEC's 1998 Reg ATS (Regulation Alternative Trading System), which established a framework for doing so, and ECNs' visibility to the market at large was increased by new SEC order-handling rules that forced Nasdaq dealers to display ECNs' prices when they were better than their own (interviewees AF and RH). Although our interviews do not suggest any conscious attempt by the SEC to foster HFT (which was only nascent in the 1990s), that was their effect. There were differences among the ECNs, but they all offered low-fee, anonymous, electronic order-book trading, with Island leading the way (interviewee AF). One of the earliest HFT firms, Automated Trading Desk, quickly realized that Island offered a material environment far more suitable for HFT (interviewees BD, BE,

BT and BW; author 2017). Other nascent HFT firms also began trading on Island and on the other ECNs as well.

These developments were the first clear manifestation of the internal dynamic of the HFT/order book *agencement*. HFT firms quickly realized, e.g., that the NQ – the Nasdaq-100 index future traded on the Chicago Mercantile Exchange – typically moved a fraction of a second before the underlying Nasdaq-listed shares. This made data on moves in the NQ (transmitted from Chicago first by fast fiber-optic cable and then microwave) a vitally important 'signal' for algorithmic share trading. The presence of HFT algorithms – especially market-making algorithms – rapidly boosted ECNs' trading volumes, while ECNs actively sought to shape their technological systems so as to facilitate HFT. As an interviewee (DB) who moved from an ECN to a HFT firm put it:

> it was the same [HFT] firms who were the big customers of Island and [other ECNs], and they all had the same wants and desires out of an electronic trading system … that's why … you start to see market structure coalesce around … low latency [i.e. fast speed], pricing tiers [lower fees for firms trading large volumes of shares], very similar [technical] functionality, because the same principal actors [HFT firms] who were feeding the same list of desires to exchanges globally and they all say 'if you do A, B, C to X, Y, Z, I will be able to do more business on your platform'.

Competition between ECNs and established trading venues was facilitated by the fact that – following a 1970s' reform pressed for by Congress – the US had a unified national system for the clearing and settlement of share transactions (described, e.g., by interviewees GV and GW). Whoever the parties to a trade were, and whatever the exchange or ECN on which the trade had been done, it was recorded, guaranteed, and processed by a single, central clearinghouse, the National Securities Clearing Corporation (NSCC). New ECNs

seem to have found it easy to interact electronically with the NSCC, and – crucially – shares bought on an ECN could therefore readily be sold on another ECN or on Nasdaq.

By the early 2000s, Nasdaq's share of the trading of Nasdaq-listed shares had plummeted, and in response it bought two ECNs and radically transformed its own market structure, moving from a dealer-client structure to a fast, open, anonymous electronic order book. The other chief established trading venue, the New York Stock Exchange, was initially protected from the ECNs by the SEC-mandated Intermarket Trading System, a slow (1970s-vintage) system that had to be used by venues seeking to trade shares listed on the NYSE on any large scale. In 2005, however, the SEC scrapped the requirement to use this system, exposing the NYSE to full competition (interviewees RY, RZ, and EZ). The NYSE responded in the same way as Nasdaq. It too bought an ECN, and – drawing on the ECN's technology (interviewee FB) – largely transformed itself into an open, anonymous, electronic order book market. Price competition was facilitated by the SEC's imposition – in the face of fierce opposition from finance-sector incumbents (interviewee BE) – of a minimum price increment of a cent, rather than the previously standard eighth or sixteenth of a dollar. Competition among trading venues for market share forced US exchanges to open up previously private order books and grant electronic access to HFT firms. Some of the latter were immediately ready to trade at scale: 'when we really turned on [i.e., connected to] the NYSE', says interviewee AF, 'we went from doing zero to 200 million shares a day in less than two weeks'.

The HFT/anonymous order-book *agencement* thus radically transformed US share trading. Gradually, though, a process internal to the *agencement* became ever more salient (see, especially, Budish et al., 2015). If prices start to move, market-making algorithms need to be able very rapidly to cancel their 'stale' bids or before another HFT algorithm 'picks off' (executes against) these stale prices. This forces HFT market-making firms operating in

anonymous order books into a relentless, expensive speed race with algorithms that seek to pick them off, and so gives them an incentive to experiment with market structures quite different from anonymous order books (such as the bilateral arrangements discussed below).

The Agencement *in Europe*

The emergence of a costly speed race at the heart of the HFT/order-book *agencement* did not stop US HFT firms being very successful. They therefore sought to replicate that success elsewhere. HFT in European shares was, however, initially unsuccessful. In the early 2000s, most European share trading took place either in a dealer-client market (in which the dealers were mainly London-based investment banks) or on 'national champion' exchanges such as the Paris *Bourse* and London Stock Exchange – which, despite their long histories of face-to-face trading, had already switched to electronic trading and had successfully warded off sporadic challenges from rival pre-HFT electronic trading venues (Muniesa, 2003; Pardo Guerra, 2010). The US HFT firm for which interviewees AF and BF both worked 'had all the [exchange] memberships lined up', but found that '[o]ur exchange costs, our clearing costs, … all these costs' were 'way too high' for HFT market-making to be viable: '[i]t was too expensive for us to trade' [BF].

HFT in European shares thus encountered an economically inimical environment. A fundamental actor-network claim, however, is that *agencements* can potentially transform what appears to be their external context. AF's and BF's US-based HFT firm was heavily involved in doing just that: BF, for example, reports proposing to the US ECN-provider Instinet that it should create a new pan-European ECN. The chief difficulty faced was clearing. Unlike the situation in the US, with its single, nationwide clearinghouse, Europe had, and still has, multiple clearinghouses, often with close links to existing exchanges.

Those clearinghouses seem not to have been enthusiastic about a new ECN, so Instinet's new European ECN, Chi-X, ended up persuading the Belgo-Dutch bank Fortis to set up an entirely new clearinghouse, the European Multilateral Clearing Facility (EMCF), with much lower fees than the existing clearinghouses. Chi-X launched in April 2007, promising share trading that was 'ten times faster, ten times cheaper' than the established exchanges (interviewee EA). In October 2008, the US ECN BATS launched a European arm similar to Chi-X, also initially with the EMCF as its clearer.

As in the US, these new European share-trading venues were facilitated – in Europe, largely inadvertently – by changes in regulation. Although there was widespread agreement among European Union (EU) policy-makers and politicians that 'the capital markets union project' – the integration of national markets into a single EU-wide market – was, in the words of one of those politicians, 'a flagship piece of work', there was persistent disagreement on how best to achieve it (described, e.g., by interviewees SC and II). The generally neoliberal UK, '[s]upported by a bloc [including] the Netherlands … Ireland and … the Scandinavian countries' (SC) faced a bloc usually headed by France (including Spain, Italy and sometimes Germany) that wished, inter alia, to protect 'national-champion' exchanges (see Quaglia, 2010). The influence of the latter bloc can be seen, for example, in the EU's 1993 Investment Services Directive, which permitted member states to impose 'concentration rules' that de facto required market participants to route orders only to national stock exchanges.

After 'bitter and complex' negotiations and 'fierce clashes between the incumbent stock exchange sector and the emergent brokerage/OTC [i.e. dealer-client] sector' (Moloney, 2014, p. 438), the European Union's Markets in Financial Instruments Directive (MiFID I, as it is now known) was approved in 2004. The clashes had not been over new ECN-like trading venues, none of which yet existed in 2004, but the new venues nevertheless benefitted from

MiFID I. Just as Reg ATS had done in the US, MiFID I created a clear procedure for setting up a 'multilateral trading facility' or MTF, and the 'best execution' requirement that MiFID I imposed on dealers made it more difficult for the latter to ignore the new venues when their prices were better than those on incumbent exchanges. Pressure – some commercial, some from Brussels policy-makers – was brought to bear on Europe's other share-trading clearinghouses to 'interoperate' electronically with EMCF (interviewees EA and BF), and, just as in the US, a more integrated clearing system facilitated competition among trading venues. Above all, in the words of a senior figure in one of the new venues, 'MiFID I broke the concentration rules. … BATS and Chi-X wouldn't be here probably' if those rules had remained in place (interviewee GX).

The *agencement* as it took root in European share trading closely resembled the US original. The *agencement*'s dynamic was nearly identical: new, fast, cheap trading venues, with 'tick sizes' often smaller than those of the established venues, facilitated HFT, while HFT helped those venues grow. Initially, for example, Chi-X's share of European stock trading was a mere 1-2 percent. Then, data given by Chi-X to economist Albert Menkveld show, an HFT market-making firm began to trade on Chi-X: our interviews suggest that this was the US firm that previously had to abandon trading European shares because it was too expensive. Menkveld's data reveal that the prices of the bids and offers in Chi-X's order book improved quickly and dramatically – there was 'a 50% drop in the bid-ask spread' – and Chi-X 'jumped to a double-digit share' of the European market. By 2011, the 'challenger' Chi-X had surpassed all the incumbent exchanges to become Europe's largest-volume share-trading venue (Menkveld, 2013, pp. 713-714).

A Partial Colonization: The Trading of US Treasurys

The telephone-based dealer-client *agencement* in Treasurys dates from the 1920s (Meeker, 1930, p. 260). Substantial increases in government borrowing during the Second World War led to the Department of the Treasury and its bond-market agent, the Federal Reserve Bank of New York (FRBNY), liaising closely with Treasurys dealers (McCormick, 2019). In 1960, the FRBNY began to designate selected banks and securities firms as 'Primary Dealers'. These firms took on obligations to bid in the initial auctions of Treasurys, and coordinated the subsequent trading of them. Dealers used – and still use – the interdealer market to unwind the positions they took on in trading with clients. In the 1980s, this was also done by voice, over the permanently open telephone lines connecting each individual trader at each dealer with the half dozen or so interdealer brokers. Originally, interdealer brokers would repeatedly relay 'runs' – lists of prevailing prices – verbally to dealers, but by the 1980s all the main interdealer brokers firms used visual display screens to distribute prices to dealers (interviewee XV): see Figure 3. Providing these price screens to *clients* was, however, taboo. When the interdealer broker RMJ Securities started to do this in the late 1980s, it 'blew up on them, right?' (interviewee XV). RMJ 'lost almost all of their [interdealer] business overnight' (interviewee XP). Within a week, the firm reversed course, retreating to its traditional role as an intermediary between dealers.

The biggest of the interdealer brokers, Cantor Fitzgerald, was, however, not as easily disciplined as RMJ. Its screens were widely regarded by dealers as an indispensable guide to the interdealer market, and it was able, without retaliation, to give at least some non-dealers (Chicago pit traders who traded bond futures) access to those screens. Originally neither dealers nor the Chicago firms could directly place bids and offers on the screens that interdealer brokers provided: they had to ask a broker to do so. In 1999, however, Cantor Fitzgerald made its internal electronic system (rechristened 'eSpeed') 'accessible through your own keyboard and through your own ability to input trades' (interviewee YD), giving

dealers direct access to Cantor's electronic interdealer Treasurys order book. Dealers' clients were not given access to eSpeed, but incumbent dealers nevertheless feared that sooner or later Cantor 'was going to disintermediate banks' (interviewee XO). '[W]e [major dealers] got together', says XO, 'and said let's put this consortium [of dealers] together so that [clients] can directly access our bids and offers and not go through Cantor'. The result was Tradeweb, launched in 1998, an electronic trading system that was *not* an anonymous order book, but rather a means of automating the process of an institutional-investor client telephoning a small number of dealers to ask them to quote prices, in an interaction in which each party knows the other's identity. As an innovation that respected the dealer-client distinction, and required only modest changes to existing work processes, Tradeweb was strikingly successful. Nor were the major dealers content to allow Cantor's eSpeed to dominate electronic interdealer trading. As one dealer puts it: 'you couldn't deal with one guy. You just couldn't deal with one guy (interviewee XO). Another consortium of major dealers, BrokerTec, was formed, and in 2000 it launched a rival anonymous electronic interdealer trading platform.

The HFT/order book *agencement* fell into place. HFT firms had gained expertise and capital trading shares, and started to put out feelers to BrokerTec and eSpeed. The trading platforms anticipated some dealers being 'pretty upset that the market was now being diluted' (interviewee CA), but also knew that giving HFT firms access could increase trading volumes markedly. Once one platform allowed HFT firms in, the other had to do so too. As interviewee AB, whose HFT firm became heavily involved in the interdealer Treasurys market, said, 'it was very important for us to be operating on both [BrokerTec and eSpeed] … because then one wouldn't kick us off, out of fear that we would help the other take more market share'. By the time dealers realized they now had formidable competitors – HFT

firms are 'way faster, they're picking-off the dealers [executing against dealers' price quotations that had not been updated quickly enough]' – 'it was too late' to resist.

As in share trading, the *agencement* utterly transformed the Treasury's interdealer market. For example, both BrokerTec and eSpeed had a feature known as the 'work-up protocol' – deeply irritating to high-frequency traders such as interviewee AC – that paused trading when a deal was struck to give the two parties to it (assumed to be human beings) the chance to negotiate a larger transaction at the same price. This pause, a practice inherited from how human brokers orchestrated interdealer trading, was gradually made shorter and shorter, leaving eSpeed and especially BrokerTec structurally very similar to *agencement*-transformed share trading. In 2012, indeed, BrokerTec began leasing Nasdaq's ultrafast Genium Inet share-trading matching engine technology. In 2013, Nasdaq itself bought eSpeed from Cantor. By 2015, only two of the ten largest-volume trading firms on BrokerTec, which has become the dominant interdealer platform, were dealers (JP Morgan and Barclays). The other eight were all HFT firms. In little more than two months of 2015, the eight HFT firms had traded Treasurys worth around $7 trillion: see Table 5.

The agencement*'s limits: Direct Match and bilateral trading*

Despite some dealer unhappiness, neither BrokerTec nor eSpeed faced a revolt against allowing HFT algorithms into the interdealer Treasurys market. What dealers 'really cared about more', says interviewee CA, 'was not having client flow on screen' – in other words, ensuring that clients continued to trade only via dealers, not directly. In 2016, though, a new anonymous electronic order-book trading platform, Direct Match, designed to allow clients to trade not just with dealers but with each other, was ready for launch. It was a controversial initiative – 'it can be a career-threatening thing' simply to invite a representative of a platform of that kind to give a presentation at a major dealer, says former dealer GN – but the

timing seemed promising. As noted, the largest dealers are all banks, and the more stringent capital requirements imposed by regulators since the financial crisis have considerably reduced banks' willingness and/or capacity to hold large inventories of bonds. Direct Match was, in effect, an effort to create for the Treasurys market an equivalent of Island, the ECN via which the *agencement* had begun the process of changing the trading of shares. Direct Match's matching engine was built to the same basic design as Island's, and – just as Island had – it planned to offer a smaller 'tick size' than BrokerTec's and eSpeed's. If Direct Match had succeeded as Island had, the *agencement* would likely have transformed the entire Treasurys market, not just its interdealer segment.

The chief obstacle to Direct Match turned out to be clearing. In anonymous trading systems, a central 'clearinghouse' normally stands in between the two parties, preserving anonymity and protecting each party from a default by the anonymous other. In the Treasurys market, that role is played by the Fixed Income Clearing Corporation (FICC), making it essential for a trading platform to have access to FICC. The qualifications for FICC membership, however, are daunting – 'a net worth of at least $25 million and cash on hand of $10 million or more' (Smith, 2016, p. 44) – and Direct Match, as a small start-up, could not itself meet them. It had, however, secured the apparent agreement of a major bank that was a FICC member to handle the clearing of trades on Direct Match. Around a week before Direct Match was due to launch, though, the bank 'stopped answering calls. Finally get them on the phone and they bail out of it, citing conflicts [of interest]. Never really got explained' (interviewee CC). Without access to FICC, and unable to raise the $25 million for FICC membership, Direct Match never launched.

Direct Match had sought to emulate the open, anonymous, order-book trading of shares. Share trading had also seen the emergence of dark pools (electronic trading venues in which the order book is not visible to participants). Interviewee CC's HFT firm, for example,

had successfully set up its own share-trading dark pool, but 'the technology force[d] us', however, to take a different route in Treasurys, he reports. The single most important technical system via which participants in the Treasurys market make trading decisions is the Ion aggregator, which collects bids and offers on display across the market. A dark pool with a hidden order book would have been invisible to the Ion system and thus to the majority of market participants. HFT market-making firms therefore did not try to create dark pools for Treasurys trading. Nor, in general, have they sought to trade directly with dealers' clients, because cultivating these clients would mean spending money with no certainty of success. Instead, HFT firms have sought to supplement their activity on BrokerTec and eSpeed with direct bilateral trading arrangements with individual dealers: at first, mid-size Treasurys dealers, then more recently even the very largest dealers. In an arrangement of this kind, the HFT firm streams electronically executable Treasurys prices to the dealer – prices that can, e.g., be incorporated into the dealer's Ion system – while (in some cases) the dealer's systems also stream executable prices to the HFT firm. For the latter, this private bilateral arrangement is attractive because its algorithms are not at risk of being 'picked-off' by faster HFT algorithms, so the HFT firm can offer better prices than in anonymous order-book markets, which in turn makes bilateral trading with an HFT firm attractive to dealers.

What is fascinating about these private, non-anonymous bilateral arrangements is that HFT firms are careful not to exploit the greater speed of their systems:

> if Goldman is leaving a stale price on their book … and I then lift that price … I'm going to get a phone call from Goldman saying, 'hey … that was a bit painful, cut it out', or we can amend [the transaction]. And we do. … There are times where our own strategies will lock down [shut off automatically] if we've made too much [profit] (interviewee CA).

The colonization of Treasurys trading by the HFT/anonymous order-book *agencement* is thus limited in scope essentially to BrokerTec and eSpeed: the dynamics of trading in the non-anonymous bilateral arrangements are quite different from those of trading in anonymous order books. What perhaps is most striking about the processes leading to this outcome is the absence in the Treasurys market of any trace of government intervention, which is such a significant part of the processes leading to the triumph in share trading of the HFT/anonymous order-book *agencement*. The Department of the Treasury is ever-present as the borrower, and its agent, the FRBNY, created and supervises the Primary Dealer system, but with only two real exceptions (Gabor, 2016; Scraggs 2016) government agencies have not intervened in recent decades to influence the structure of the Treasurys market, and, furthermore, neither exception is dramatic.

Why the lack of state intervention in the market structure of Treasurys trading? '[R]emember, today is a Thursday,' a former Department of the Treasury official (interviewee VS) told us in October 2016. On most Thursdays – indeed, most working days – Treasurys need to be sold: 'Usually Monday through Thursday, there is one or more auctions that take place, and a Primary Dealer, whether you like it or not, you have to submit your bids.' For the Department of the Treasury, that obligation is 'reassuring', says VS, and the Primary Dealer system gives the FRBNY the capacity to 'use moral persuasion.' The Treasurys market 'is not like the equity market. … This market is special. … It's the market that finances the sovereign' (interviewee VS). The US very likely could continue reliably to sell Treasurys without the aid of Primary Dealers, but policy-makers cannot be certain of that in advance. Those Primary Dealers thus enjoy what Braun (2018) labels 'infrastructural power' – the power that private actors accrue by being part of mechanisms by which states act financially – which greatly limits the appetite of policy-makers for measures that would enhance competition but might cause banks no longer to be prepared to take on the

obligations involved in being a Primary Dealer. In the resultant absence of the government action found in share trading, the HFT/anonymous order-book *agencement* has been able only partially to alter that market structure.

An *agencement* blocked: sovereign bonds in Europe

The HFT *agencement*'s success in European sovereign bond trading has been even more limited. As in the US, trading is bifurcated, with separate interdealer and dealer-client markets. Although telephone trading remains important, there are mature systems for electronic trading in both markets. As in the US, clients use Tradeweb's and Bloomberg's systems (or the dealer-client system of MTS, for which see below) electronically to request price quotations from primary dealers.

The hugely salient difference from the US is that no HFT firm has gained access to any European sovereign bond interdealer market. The UK interdealer market remains dominated by voice brokers (as, e.g., interviewee FZ reports). The Eurozone interdealer market is more comparable to the US, because there is a long-established, heavily used interdealer electronic platform, MTS. Founded in 1988 as the *Mercato dei Titoli di Stato* by Italy's Treasury and central bank, MTS was privatized in 1997 and gave birth in 1998 to a pan-European interdealer platform, EuroMTS. BrokerTec and eSpeed also launched European sovereign bond trading platforms, but by 2006 their joint market share was only 0.1 percent (Persaud, 2006, Table 1), and our interview data make clear that they remain entirely overshadowed by MTS. In the words of interviewee EK, MTS became:

> … almost part of the European *acquis* [the body of rights and obligations of EU member states]: if you became part of the Euro, in particular, you had to have your MTS market, because that gave you not only bond trading but … also … repos [the

capacity to buy bonds with loans collateralized with those bonds] which were critical for the money markets.

Governments, primary dealers, and MTS became part of what the MTS Group (2003, p. 3) described as a 'Liquidity Pact'. This involves, primary dealers, which – as in the US – are nearly always large banks (see the lists in AFME, 2017), taking on commitments to bid in primary auctions and facilitating subsequent trading by 'adhering to specified criteria' for the continuous posting of executable price quotations (MTS Group, 2003, p. 3). These bidding and market-making obligations can easily be loss-making (interviewee YB; see Lemoine, 2013), but banks continue to act as primary dealers in part for fear of being 'put on a … list' (YB) and informally excluded from more profitable government business such as debt syndications – transactions the US does not undertake – and to a lesser extent potentially also privatizations.

In 2006, US-based HFT firms – by then trading successfully on BrokerTec and eSpeed in the US – began approaching MTS for access. In Europe, though, MTS was sufficiently dominant that there was no equivalent of the fierce battle for market share between BrokerTec and eSpeed that had facilitated the entry of HFT. There was, however, criticism – e.g. in a report (Persaud, 2006) commissioned by the London-based interdealer broker ICAP, which had bought BrokerTec – of rules that (e.g. in Italy) designated MTS as the platform on which primary dealers had to fulfil market-making obligations. When requests for access from HFT firms started to arrive, MTS's leadership – which had ambitions for growth and international expansion (Chung & Tett, 2006) that HFT might have facilitated – 'felt the need to listen [and] started a conversation' (interviewee YB).

In the US, the competing interdealer platforms had given access to HFT firms without publicity and without (as far as we can tell) seeking permission from the Department of the

Treasury or FRBNY; as noted above, by the time dealers fully realized what had happened, effective resistance was impossible. In Europe, in contrast, most likely because of MTS's semi-official role in the Eurozone[8], MTS decided to speak publicly about the 'conversation' with HFT before allowing HFT firms to trade on the system. MTS's Chief Executive talked to the *Financial Times* about it (Chung & Tett, 2006). The reaction from dealers was fiercely hostile. While the tone of the European Primary Dealers Association was measured – 'Allowing third party access … may upset the delicate balance in the euro government bond market' (quoted in Chung & Tett, 2007) – behind the scenes some in 'the dealer community … just went berserk. They literally went berserk' (interviewee YB) and 'threatened to stop using MTS all together' (interviewee SF). One banker warned the *Financial Times* that 'People are furious. You could end up with a full-scale rebellion … that could rip the system apart' (Chung & Tett, 2007).

The controversy, reports interviewee YB, cost several of MTS's senior executives their jobs, and any suggestion of allowing HFT firms access to MTS seems to have been shelved indefinitely. HFT interviewees describe UK, Eurozone, and other European interdealer sovereign bond trading as impossible to access: '[t]hey wouldn't let us on' (interviewee BU); it's 'a club that we can't get into' (AG).[9] This is not arbitrary exclusion but a matter of explicit rules and taken-for-granted understandings. Rules include, e.g., minimum

[8] The rapid expansion of MTS was promoted by primary dealers who embraced the platform (SF), because it reduced their need to risk capital by trading on other platforms. As one European regulator put it 'we were quite happy how the market [for electronic bond dealing] organized itself' (SE). Persaud (2006) estimates that by 2005 MTS platforms account for over 70 percent of electronic European cash government bonds trading.

[9] The only European sovereign-bond HFT we have found takes place on a relatively small scale on the Bolsa Italiana, which has made 'government bonds … tradeable electronically just like [shares] and … centrally cleared' (interviewee CR). Trading is informed by prices in the interdealer market, which (bizarrely for HFT) sometimes have to be gleaned via telephone calls.

capital requirements for participants in interdealer markets that considerably exceed the sums available to most HFT firms (for a sample of requirements, see AFME, 2017). The taken-for-granted understanding is that 'membership is limited to institutional intermediaries (essentially banks)' (Ministero dell'Economia e delle Finanze, 2017, p. 11).

Rules can of course be changed, and tacit understandings challenged, but European governments – however neoliberal their overall ideologies – have not done so. According to a European regulator interviewed, this was indeed 'not a matter of culture. Look at the Netherlands, Ireland or Germany, these are all neoliberal countries in terms of financial markets. They would do it [allow HFT in their bond markets] if they thought it bought advantages to them' (SG). The energetic EU reforms from the early 2000s onwards of the market structure of share trading (the elimination of concentration rules, for example) have not been echoed in the trading of sovereign bonds. As interviewee SC, a politician heavily involved in regulatory reform, told us:

> dealers … have to be authorized by [government debt management offices] to participate. … [P]roprietary trading houses [such as HFT firms] would not meet the criteria … in most cases.
>
> First author: [Do] you get a sense that people in the regulatory/political sphere are perfectly content with that?
>
> Interviewee SC: They can control a small number of dealers, so they can control their primary issuance [the initial auctioning of sovereign bonds] in a way they wouldn't be able to if they actually took it totally and utterly to a much broader audience.

Interviewee CR, for instance, reports the Italian Ministry of Finance as being 'uncomfortable with non-banks' such as HFT firms, because their entry would further reduce 'the profitability of being a primary dealer' and potentially threaten banks' willingness to take on

the role. In the words of one debt management official: 'The [primary dealer] system has proved itself to be resilient, it's working, why change it?' (SH). This assessment was echoed by a European regulator stating that 'the system works, there is no need to change it' (SI). This continued support sits alongside both the preferences of the international debt management community and international organizations' sense of 'best practice' remaining supportive of the primary dealer system in advanced economies (IMF 2014; IMF & World Bank 2002).[10] A primary dealer spells out the reasons for governments' reluctance to be swayed by HFT firms' argument that 'algo trading makes the market more efficient':

> you can shout and scream as much as you want and you call about clubbing [barriers to entry] but … if I'm an Italian [government] debt manager and I have [€] two trillion debts to service of which [€] 300 billion a year to issue, I don't care if you're a hedge fund in America and you talk to me about price efficiency. Go and take a hike. … [I]f you want to come, guarantee to me that you're going to buy 3 percent of my debt and get a banking licence, come on board. If not, go to hell … if I'm a sensible regulator, I'm a sensible politician, do I really want to cater for my people in difficult times or do I want to cater for the profitability of these [algorithmic trading] geniuses? (Interviewee YB)

Conclusion

[10] The special status of the sovereign bond market is not to be reduced to the costs and risks of financing the state but extend well into other markets (notably shares) and policy areas (such as monetary and housing policy). In the simile of one interviewee: 'debt management is like the plumbing of the house, everybody expects it will work and nobody cares about it unless there is a crisis' (SG). The past decade of quantitative easing and historically low bond yields across a varied group of sovereign borrowers have cast doubt on the power of market discipline (cf. author, 2019, p.5). At the same time, Europe's debt crises as well as a recent string of litigation and court rulings on developing world sovereign debt have challenged preexisting conceptions of sovereignty in debt markets. Given these underlying high structural stakes and recent developments, there has then been little appetite for what is perceived as risky innovation.

Factors of two broad kinds can be seen at work in the development of market structure in the four cases we have examined here (and, indeed, in the other classes of financial instrument covered in our broader research). Factors of the first kind include the components of the HFT/anonymous order-book *agencement*: fast matching engines, fast data dissemination to algorithms and fast order placement by those algorithms, small 'tick sizes', microwave links, and so on. These components are, broadly, technical, but not *just* technical. They are *socio*material in at least two senses: they are not technically inevitable, but unconscious or conscious choices as to how to design the large technical network that share trading (and also interdealer Treasurys trading) has become;[11] and they have in their ensemble major socioeconomic effects, transforming traditional exchanges and largely sweeping aside dealer-client trading of shares. Technical components of the dealer-client *agencement*, such as the Ion aggregator, have been less dramatic in their effects, but are important nonetheless. Ion's central role, for example, seems to have helped push change in Treasurys market structure away from the path followed in share trading and towards the intriguing bilateral arrangements sketched in that section of this article. The development of market structure cannot be understood in abstraction from that structure's materiality.

All of that is entirely consistent with 'actor-network' analyses of markets of the sort inspired above all by Callon (1998, etc.). Yet factors of a second kind – much less frequently invoked in actor-network analyses – are also prominent in our narratives: the conflict between incumbents and challengers and the diverse roles of the state and its agencies in the outcome of such conflicts. In the cases of both US and European shares, the crucial role of government regulators has been to promote of competition. Sovereign bonds are quite different. States *have* intervened in the structure of the markets for sovereign bonds, but

[11] Electronic trading, for example, does not have to be continuous, but could take the form of frequent discrete auctions, which would largely eliminate the speed race (Budish et al., 2015).

where the enhancement of competition has been the goal, this was within a clearly demarcated dealer-client boundary.[12] What is more, – some minor 'tweaks' aside – these interventions were not recent. The last major US government intervention in the structure of the Treasurys market was the creation of the primary dealer system in 1960; substantial market-structure interventions by European governments were largely complete by 2005.

Different agencies of the state do not, of course, always act consistently one with the other. While finance ministries and debt management offices in both the US and Europe remain committed to the primary dealer system (and thus, implicitly, to a dealer-client market structure), banking regulators have, as noted, weakened dealers' capacity or willingness to hold inventories by imposing more stringent capital requirements. Furthermore, the consequences of state action (or inaction) vary according to circumstances, and those circumstances include existing market structure. That the 'club' of sovereign bond trading remains essentially closed to HFT in Europe, while partly open in the US, is most likely explained in part by the way in which the dealer-client structure in European sovereign-bond trading is a result of deliberate government initiatives – a result that governments scarred by the Eurozone crisis may lack the confidence to allow to be altered even partially: Braun's (2018) 'infrastructural power' is perhaps relevant here. As Culpepper (2015) cautions, clearly identifying the structural power of any business is particularly difficult in cases involving a congruence of interests, as was arguably the case when HFT firms were excluded from MTS. The 'if-it-ain't-broke-don't-fix-it' attitude of our DMO interviewees is only congruence on one level, however; HFT claims of greater liquidity and tighter dealing spreads were seen as justifying close consideration. A less direct effect also seems to be involved in the likelihood of change. In the US, for the largely idiosyncratic reasons explored in our discussion of

[12] An example for this boundary-respecting competition is the decision of a few Eurozone countries to use BrokerTec alongside the MTS system for electronic bond trading in 2008.

Treasurys, the interdealer market had two fiercely competing electronic platforms – one set up by the leading inter-dealer broker Cantor Fitzgerald and the other set up by a consortium of dealers alarmed by Cantor's dominance – that HFT firms could, as it were, implicitly play off against each other. In Europe, in contrast, there has been only one interdealer electronic platform with any substantial volume of trading: MTS – a platform, furthermore, that was tightly bound in to the creation of the Euro and of a Eurozone-wide sovereign bond market.

It is, of course, easy to think that actor-network and political economy (e.g. field theory) perspectives involve intrinsically incompatible ontologies: that, for example, was very much the perception in France when actor-network theory first became prominent. As we have argued elsewhere, however, we see their differences as, at least in part, an empirical matter rather than an a priori ontological one (author, 2019). Furthermore, some of the phenomena we have examined straddle the apparent material/political divide almost explicitly. 'Infrastructural power' has material foundations, and clearing – differences in the arrangements for which have major effects, for example facilitating change in market structure for US shares and inhibiting it in Treasurys – is a material process (for an actor-network analysis of clearing, see Millo et al., 2005). Because market participants usually realize how important clearing is, its arrangements can be deeply controversial – with, for example, actors from the political system recruited to battles over proposed changes. (An example from our wider study is futures trading. There, competition between exchanges is greatly inhibited by 'vertical silo' clearing arrangements in which each futures exchange owns and controls its own clearinghouse, and can refuse to clear competing versions of the exchange's products. At the time of writing, there is fierce subterranean struggle in Europe over these clearing arrangements.[13]) In all the classes of financial instrument we have

[13] Europe's January 2018 MiFID II regulations include 'open access' rules governing clearing that would end 'vertical silos', but these rules were put on hold until July 2020 because of Brexit. Germany's Ministry of

examined, we have found the arrangements for clearing to be a pervasively important facilitator of or barrier to changes in market structure.

We do not claim, however, to have offered a definitive analysis of what can therefore perhaps best be called the material political economy of market structure, even in the four cases examined here. A more adequate analysis would, for example, have to disaggregate 'Europe' into its different states, because different countries, even within the Eurozone, have somewhat differently structured sovereign bond markets: practices in the German market, for instance, are heavily influenced by the tight link between *Bunds* and the interest-rate futures traded by the Frankfurt-based futures exchange, Eurex. Nevertheless, we hope that our analysis has shown both that it can be productive to focus on the politics of market structure, and that quite different intellectual traditions need to be combined in order to understand the intricate contours of that politics.

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Finance seems to be pushing hard to have the rules reconsidered during Germany's 2020 Presidency of the European Union. Germany hosts Eurex, Europe's leading futures exchange.

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Table 1. Ideal type descriptions of the dealer-client *agencement* and the HFT/anonymous order-book *agencement*.

	Dealer-client *agencement*	HFT/anonymous order-book *agencement*
Style of trading	Slow and non-anonymous; interpersonal relationships are important; price increments with relatively large 'tick sizes'	Fast and anonymous; interpersonal relations are relatively unimportant; price increments with relatively small 'tick sizes'
Structure of exchange	Market consists of an inter-dealer and dealer-client segment; interdealer segment intermediated by inter-dealer brokers; dealer-client segment intermediated by (primary) dealers	Bids and offers are aggregated in a central limit order book, which can be directly accessed by HFTs
Focus of competition	Human-centred; social mechanisms of trust and defiance are relatively important. Large investment banks tend to have competitive advantage	Technology-driven; technical expertise and organisational efficiency are relatively important. HFTs tend to have competitive advantage
Dominant trading technology	Trading in dealer-client segment phone-based, or screen-based with 'request for quote' software replicating phone-based interaction; price dissemination in inter-dealer segment sometimes screen-based.	Bids and offers placed and executed by algorithms; orders are aggregated in the datacentres of electronic exchanges

Table 2. The relative presence of the two *agencements* in the main classes of highly liquid financial instrument

	US	**Europe**
Shares	**Dominated by anonymous order books and HFT**	**Dominated by anonymous order books and HFT**
Sovereign bonds	**Dealer-client market, but with anonymous order books and HFT in interdealer trading**	**Almost intact dealer-client market**
Futures	Dominated by anonymous order books and HFT	Dominated by anonymous order books and HFT
Foreign exchange	Dealer-client market; partially colonized by anonymous order books and HFT	Dealer-client market; partially colonized by anonymous order books and HFT
Listed options	Dominated by anonymous order books but not HFT	Some anonymous order-book trading but much dealer intermediation
Interest-rate swaps	Despite anonymous order books, largely intact dealer-client market	Despite anonymous order books, largely intact dealer-client market

Sources: authors' interviews. The four cases focused on in the article are in bold.

Table 3. Proportion of trading that is dealer-intermediated in selected markets (2015 unless otherwise indicated)

US shares	17%
European shares (2018)	19%
US Treasurys	65%
UK Gilts	90%
German Bunds	>95%
Foreign exchange	60%
Interest-rate derivatives (e.g. swaps)	90%

Sources: Anderson et al. (2015), Cave (2018).

Table 4. Interviewees

Founders, employees or former employees of HFT firms (AA-DC)	80
Dealer, brokers and brokerdealers (XA-YE)	31
Exchange, clearing house, and other trading venue members and staff (EA-HC)	81
Manual traders (MA-ML)	12
Traders for investment-management firms (IA-IJ)	10
Practitioners of other forms of algorithmic trading (OA-OV)	22
Regulators, lawyers, lobbyists, debt management office staff and politicans (RA-SI)	35
Suppliers of technology and communications links (TA-UD)	30
Researchers and market analysts (VA-VT)	20
Total	321

We use two-letter codes to preserve interviewees' anonymity.

Table 5. Most active participants in BrokerTec in May and June 2015 by trading volume

	Volume (billions of US dollars)	Share of 'top ten' volume
Jump	2,291	28.5%
Citadel	1,004	12.5%
Teza	905	11.2%
KCG (Knight Capital Getco)	798	9.9%
JP Morgan	649	8.1%
Spire-X (Tower)	564	7.0%
XR Trading	554	6.9%
Barclays	483	6.0%
DRW	400	5.0%
Rigel Cove (Virtu)	400	5.0%
Overall total volume	8,049	

Source: BrokerTec unpublished list, as reproduced by Smith (2015). As Smith notes, the top-ten volume seems to exceed the total volume that can be inferred from BrokerTec's reports of average daily volumes in May and June 2015, so top-ten volume is most likely being measured over a slightly longer period. The dominant role of HFT firms, particularly Jump, is however consistent with what interviewees report.

Figure 1. An order book

(hypothetical, but based on authors' interviews and observations of electronic trading).

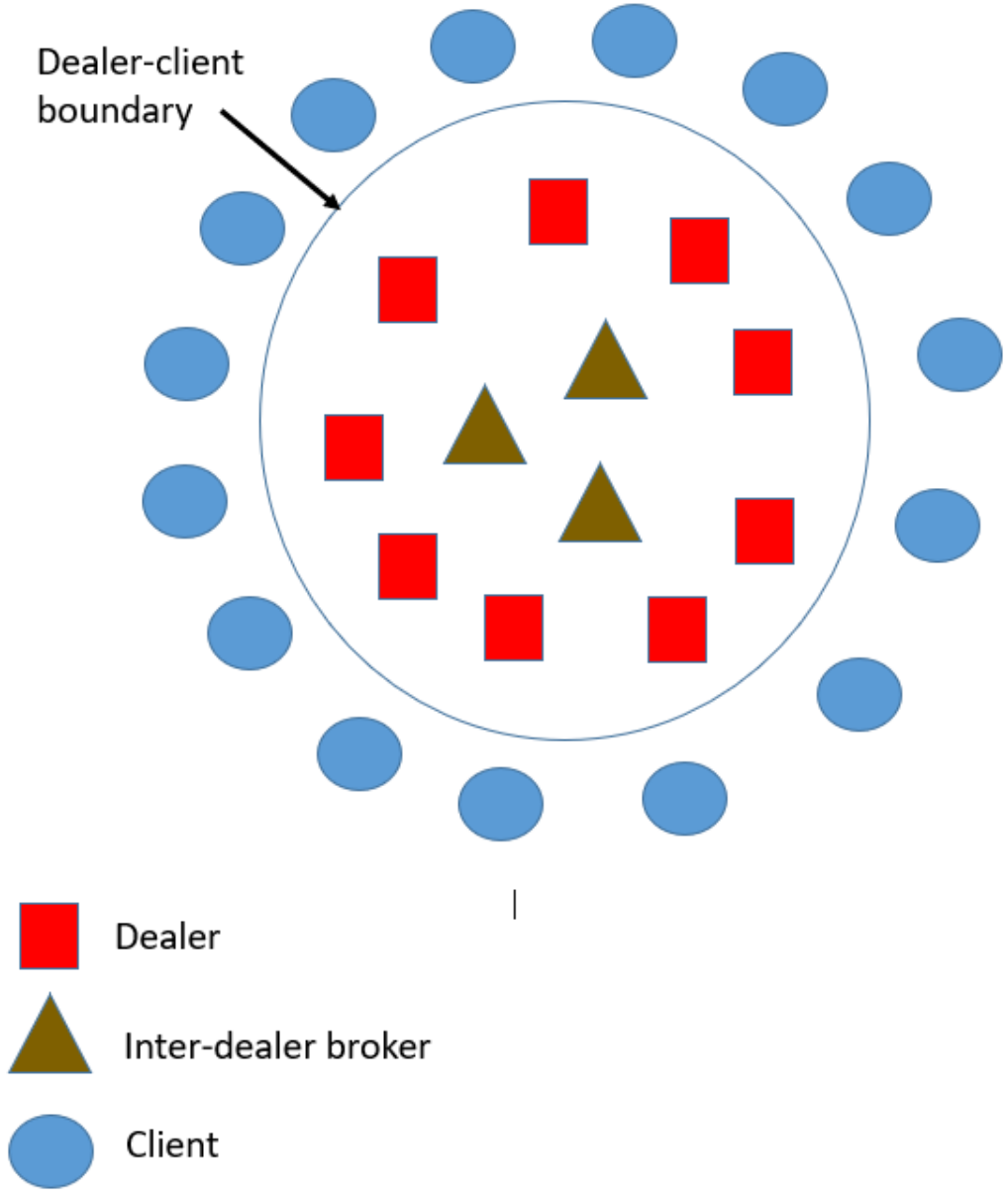

Figure 2. The typical structure of a dealer-client market.

Figure 3. Traders' desks at a Treasurys dealer, late 1980s. Source: interviewee XU.